CHEMICAL & ENGINEERING NEWS

C&EN

APRIL 13, 1992

TOP 50 CHEMICAL PRODUCTION CHANGED LITTLE LAST YEAR PAGE 16

CHEMICAL INDUSTRY OF FORMER U.S.S.R.

Starting tough transition to market economy Page 46

CHEMICAL & ENGINEERING NEWS

C&EN

APRIL 13, 1992

NEWS OF THE WEEK

■ House hearings probe how government sets research priorities. Page 4

■ ACS national meeting in San Francisco last week set records in attendance and in the size of its technical program. Page 4

■ Herman Mark, a founding father of polymer science, dies at 96. Page 5

■ New light-sensing device based on molecular dye and high-temperature superconductor can respond selectively to different colors of light. Page 6

■ Immunex is suing Hoechst A.G. and two subsidiaries over GM-CSF, a drug to stimulate white blood cell growth. Page 6

■ Preparatory negotiations for UN Conference on Environment & Development end with major issues unresolved, dimming prospects for global agreements to protect the environment. Page 7

■ Astronauts on space shuttle study atmospheric chemistry during nine-day mission. Page 7

■ Two new approaches to making the anticancer drug taxol have been devised. Page 8

COVER: Nizhnekamsk Petrochemical Combine, located in the Volga region of Russia, is the republic's largest source of ethylene. Photo by TASS/SOVFOTO

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BUSINESS

Production of Top 50 chemicals stagnates in 1991, with organic production increasing only 3% and inorganic production decreasing 1%. Page 16

Polymer production edged up a bit more than 1% in 1991 from 1990 to a new high of 62.8 billion lb. Page 20

GOVERNMENT

Federal R&D budget faces cutbacks following Congressional votes to retain the budgetary "fire walls" that prohibit the swapping of funds among defense, domestic, and international programs. Page 27

National Academy of Sciences panel will consider feasibility of methods other than incineration for the destruction of chemical weapons. Page 29

New payment option to recipients of National Science Foundation Young Investigator awards offers maximum flexibility, especially for leveraging matching funds from industry. Page 30

SCIENCE/TECHNOLOGY

Polyrotaxanes, unusual complexes with two dozen or more cyclodextrin rings threaded on a polymer chain, may have applications in molecular technologies and materials science. Page 39

Environmental regulatory activity is becoming more realistic, as was emphasized by both keynote speakers at AIChE's recent annual meeting. Page 41

A new predoctoral fellowship program will provide funds to universities to support interdisciplinary training of Ph.D. students in chemistry and biology. Page 44

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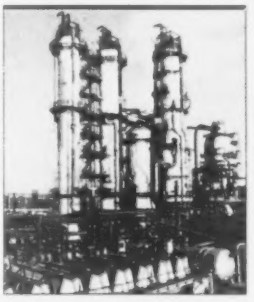

Chemical industry in the former Soviet Union, one of the largest and yet one of the most backward and inefficient industries in the world, must make a difficult transition to a market economy. Page 46

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LETTERS

Cold fusion research

Eugene Mallove (C&EN, Feb. 10, page 2) accuses Trevor Pinch and me of "arrogant misunderstanding of cold fusion research." Casting his net further, he then accuses the scientific establishment and some science media of "arrogant dismissal" of a "new phenomenon of unparalleled signficance," because we regard it as "a priori impossible." The latter, at least, is untrue, as should be apparent to anyone who read even the first three pages of "Too Hot to Handle," where I wrote, "Even though intuitive[ly we felt] that [cold fusion] was too far-fetched to be real, nonetheless it had to be checked." Mallove seems to have forgotten that vast numbers of institutions, including Department of Energy-sponsored laboratories in the U.S., Harwell Laboratory in the U.K., and other European national facilities indeed made such checks by investigating the cold fusion claims in 1989. This is hardly consistent with "a priori" dismissal.

I hope that our lack of belief in cold "fusion" is not due to arrogance, but instead to the cold-blooded analyses by many physicists, metallurgists, and chemists. The majority of scientists have now moved on from cold fusion, the revelations in "Too Hot to Handle" having tied up some of the loose ends and having raised further doubts about the original Martin Fleischmann, Marvin Hawkins, and B. Stanley Pons claims. Since writing "Too Hot to Handle," I have continued to monitor the cold fusion work, much of which is, indeed, extraordinary (though not perhaps in the sense that Mallove meant).

This leads me to the following summary of the present evidence and suggests possible interpretations. First, some cells have shown thermal balance with either light or heavy water. This set of results is showing either that there is no "cold fusion" effect at all, or that there is an unknown trigger that is missing in these "dead" cells. Second, other cells have shown thermal imbalance both with heavy water and also with ordinary water. This set of phenomena arises either because there is miscalibration or because these cells contain the unknown trigger. The electrochemical community has to decide on the former. In order to retain contact with Mallove, let's suppose that the latter is correct. My conclusion is that this trigger has the features of chemical/atomic and not nuclear reactions because the effect is of similar magnitude with heavy and light water and no nuclear products have been found commensurate with the claimed amounts of heat.

The "well-established ... tritium, neutrons, charged particles" cited by Mallove are less impressive than his letter might suggest: They are seen sporadically, if at all, in uncorrelated fashion, and fail by orders of magnitude to be nuclear products from watts of power. If, as Mallove claims, the heat is reproducible, and if it is nuclear fusion (or even a nuclear "process" as the original proponents now seem to be retreating to), then the original materials turn into something—and so, I ask, why do we hear so little about these remnants? Findings of the order of 10^{12} nuclear transmutations per watt should be relatively easy, and, if found reproducibly, would prove the claims beyond all doubts. It is the strange reluctance to do this definitive test, or the a posteriori excuses when the products do not show up, that strain credibility and help to make me a skeptic.

There have been—and are still—claims to find neutrons at a level over a billion times below these. This is still under investigation by Stephen Jones and others, as great care is needed to distinguish such a weak signal from the natural background radiation. If real (and many nuclear physicists are yet unconvinced), these have no bearing on the heat claims by Fleischmann, Hawkins, and Pons, and it is misleading to lump all these together. Indeed, Jones has repeatedly distanced his work from that associated with the three researchers.

Finally, there is the myth of hundreds of papers supporting cold fusion. But many of these are, in Herman Feshbach's words, "a bunch of junk." I have discussed as many as practically possible with experts in various fields and conclude that there are perhaps a few dozen at most that merit a second look—but even among these there is no correlation, nor any one that stands out as a landmark. One claims tritium but no neutrons, and another claims neutrons that are statistically insignificant and no tritium; one claims heat with helium as a by-product, and another claims heat and no products. Yet another claims heat with ordinary water, and so on. To some this is a tantalizing hint of "esoteric reactions that violate conventional theories of physics"

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Top 50 Chemicals Production Stagnated Last Year

■ ***Although output was virtually unchanged from 1990, organics production moved up 3% while that of inorganics declined 1%***

Marc S. Reisch,
C&EN Northeast News Bureau

The economic slowdown finally caught up with chemical producers in 1991. Chemical export growth was not enough to counter the lag in most industrial markets or to help push U.S. chemical production to new heights in 1991, as it did in 1990.

According to C&EN's annual ranking of the 50 largest volume chemical products, total production in that group was virtually unchanged in 1991 from 1990. Production stagnated at the 633 billion-lb level registered the year before, which had been a good year. In 1990, production of the Top 50 rose 2% over 1989.

The Federal Reserve Board's data for 1991 also portray a commodity chemical slowdown. The Federal Reserve's seasonally adjusted indexes for basic and industrial chemical production increased less than 1%, respectively, between December 1990 and December 1991. And just as C&EN's Top 50 showed production gains in 1990 compared with 1989, Federal Reserve data indicate that between December 1989 and December 1990 seasonally adjusted basic and industrial chemical production increased (7% and 3%, respectively).

A year such as 1991 demonstrates just how much the cycle for commodity chemicals differs from that for other chemicals—for instance, specialty and pharmaceutical chemicals. These two categories are not included among C&EN's Top 50. However, the Federal Reserve's seasonally adjusted indexes show high-value pharmaceutical chemicals production rose almost 10% between December 1990 and December 1991. And plastic materials production, for instance, increased 5% during the same period.

Although the Top 50 in some ways reflects the general slowdown in business and the economy, commodity chemicals production is more a lagging indicator of economic conditions like

About the Top 50 list of chemical products

Government data, trade association figures, and industry estimates all go into preparing C&EN's annual list of the Top 50 chemical products, ranked by production volume. The federal government is relied upon most heavily, but when government figures are not available, other sources, primarily trade associations, are used. Industry sources and C&EN estimates are used only when other data are lacking.

Government data are not always accurate—they are only as good as the information that individual companies report. But they are an objective measure of production extending back many years. Therefore, relatively accurate indications of growth can be made on a consistent basis.

At this time of year, C&EN has access only to preliminary reports of production for 1991. When the government and trade associations issue their final reports, the outcome can be changed, sometimes dramatically. As a result, the production figures for earlier years that appear in the table on page 17 are different in some cases from those published in last year's Top 50 article. The final reports also can affect the rankings of chemicals. For the table on page 17, the 1990 ranking of 20 chemicals is different from last year's listing (C&EN, April 8, 1991, page 14).

The list itself covers production figures for the U.S. and includes chemicals produced for export. Candidates for the list include all basic, intermediate, and chemically homogeneous finished products. These range from chemical building blocks like ethylene and propylene to downstream products like vinyl acetate and ethylene glycol.

The roster includes basic inorganic chemicals, but does not include what C&EN considers to be minerals, such as salt, gypsum, and sulfur. Lime is included because it is processed and has many chemical and industrial applications. Refractory (dead burned) dolomite is excluded in lime production.

On the organics list, such petrochemical feedstocks as ethane, butane, and propane are excluded arbitrarily because they are considered to be products of oil companies and because they have many nonchemical uses.

There are other gray areas besides lime and petrochemical feedstocks. For example, the basic aromatics—benzene, toluene, and xylene—are included.

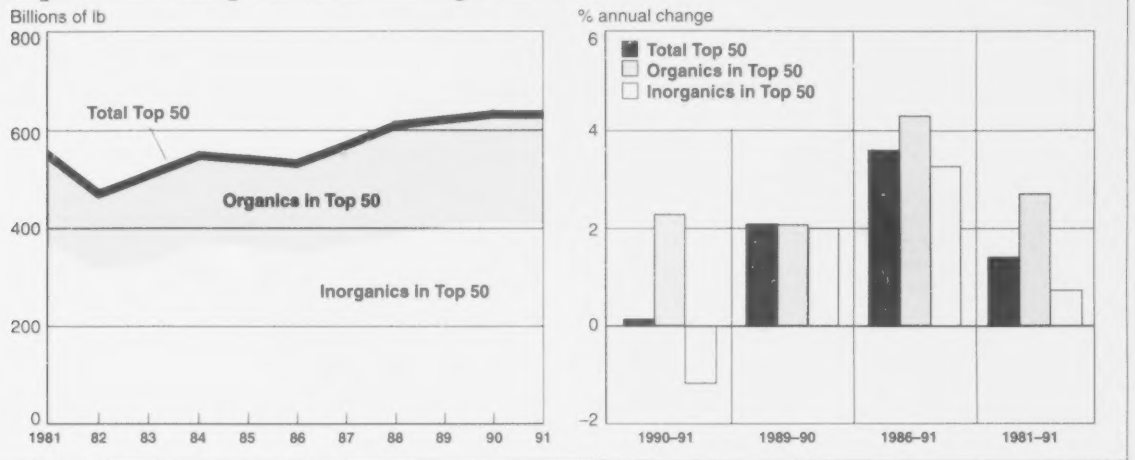
Production figures are published by the government in a variety of units—pounds, tons, cubic feet, gallons, metric tons, and most recently, kilograms and liters. Where the latter two units are used, they have been converted, where appropriate, into the common units that the government and industry have historically used as points of reference. To provide an accurate ranking and to make comparison of production volumes easier, C&EN lists production not only in common units, but also by weight in pounds.

Top 50 chemicals production totaled about 633 billion lb last year

Rank 1991	Rank 1990[a]		Billions of lb 1991	Billions of lb 1990	Common units[b] 1991	Common units[b] 1990	Average annual change 1990–91	1989–90	1986–91	1981–91
1	1	Sulfuric acid	86.62	88.09	43,308 tt	44,044 tt	−1.7%	1.7%	3.8%	0.6%
2	2	Nitrogen	57.03	56.23	787 bcf	776 bcf	1.4	4.3	3.2	4.9
3	4	Ethylene	39.23	36.47	39,231 mp	36,473 mp	7.6	4.2	3.6	2.9
4	3	Oxygen	38.99	40.48	471 bcf	489 bcf	−3.7	8.2	3.4	0.9
5	6	Ammonia	34.04	33.59	17,020 tt	16,796 tt	1.3	2.0	4.0	−1.1
6	5	Lime[c]	33.60	34.90	16,800 tt	17,452 tt	−3.7	1.6	3.0	−1.1
7	7	Phosphoric acid	24.68	24.07	12,342 tt	12,034 tt	2.6	2.5	6.0	2.2
8	8	Sodium hydroxide	24.39	24.06	12,197 tt	12,030 tt	1.4	4.9	2.7	1.6
9	9	Chlorine	22.65	23.62	11,324 tt	11,810 tt	−4.1	3.5	1.6	0.5
10	10	Propylene	22.02	21.85	22,024 mp	21,849 mp	0.8	6.2	5.9	5.0
11	11	Sodium carbonate[d]	20.50	20.18	10,249 tt	10,090 tt	1.6	1.8	4.0	2.2
12	12	Urea[e]	16.14	16.24	8,072 tt	8,120 tt	−0.6	1.4	6.0	0
13	13	Nitric acid	15.05	16.00	7,524 tt	7,999 tt	−5.9	−4.2	2.8	−1.9
14	14	Ammonium nitrate[f]	14.62	14.16	7,310 tt	7,081 tt	3.2	−10.0	5.6	−1.9
15	15	Ethylene dichloride	13.92	13.85	13,922 mp	13,852 mp	0.5	3.5	1.5	3.4
16	16	Benzene	11.78	12.45	1,600 mg	1,690 mg	−5.3	4.2	3.3	2.0
17	17	Vinyl chloride	11.70	10.63	11,695 mp	10,626 mp	10.1	4.8	6.7	5.5
18	18	Carbon dioxide[g]	9.76	10.37	4,882 tt	5,186 tt	−5.9	−2.9	0	2.6
19	19	Methyl *tert*-butyl ether	9.60	8.89	9,600 mp	8,886 mp	8.0	8.0	23.3	28.9
20	20	Ethylbenzene	9.22	8.37	9,221 mp	8,370 mp	10.2	−9.4	0.4	1.7
21	22	Styrene	9.01	8.02	9,005 mp	8,017 mp	12.3	−3.9	2.7	3.0
22	21	Methanol	8.65	8.35	8,655 mp	8,346 mp	3.7	2.2	3.7	0.1
23	23	Terephthalic acid[h]	7.66	7.77	7,656 mp	7,775 mp	−1.5	−7.8	−0.1	2.1
24	25	Toluene[i]	6.80	6.21	937 mg	856 mg	9.5	6.9	8.9	1.0
25	24	Formaldehyde[j]	6.43	6.72	6,425 mp	6,721 mp	−4.4	14.0	3.0	1.2
26	26	Xylene	6.13	6.21	851 mg	862 mg	−1.3	−4.5	6.4	−0.3
27	27	Hydrochloric acid	5.60	6.03	2,799 tt	3,013 tt	−7.1	−7.8	3.2	0.8
28	29	*p*-Xylene	5.43	5.20	5,433 mp	5,202 mp	4.5	−2.7	1.5	1.8
29	28	Ethylene oxide	5.24	5.36	5,243 mp	5,356 mp	−2.1	6.4	−0.7	0.2
30	31	Ethylene glycol	4.93	5.07	4,930 mp	5,072 mp	−2.8	−7.1	0.7	1.8
31	30	Ammonium sulfate	4.46	5.08	2,230 tt	2,539 tt	−12.2	6.5	1.3	0.2
32	32	Cumene	4.28	4.31	4,284 mp	4,311 mp	−0.6	−2.6	2.7	2.6
33	33	Potash[k]	3.90	3.78	1,770 tmt	1,713 tmt	3.3	7.4	8.0	−2.0
34	34	Acetic acid	3.61	3.75	3,612 mp	3,751 mp	−3.7	13.9	5.8	1.6
35	36	Propylene oxide	3.60	3.20	3,600 mp	3,200 mp	12.5	0	7.7	6.9
36	35	Phenol[l]	3.49	3.54	3,486 mp	3,539 mp	−1.5	−7.0	2.3	3.1
37	37	Butadiene[m]	2.91	3.09	2,913 mp	3,089 mp	−5.7	−1.1	2.7	−0.2
38	38	Carbon black	2.72	2.87	2,723 mp	2,868 mp	−5.1	−1.5	1.0	0
39	39	Acrylonitrile	2.65	2.68	2,648 mp	2,677 mp	−1.1	13.2	3.9	2.9
39	40	Vinyl acetate	2.65	2.66	2,646 mp	2,659 mp	−0.5	4.2	9.1	3.2
41	42	Aluminum sulfate	2.36	2.45	1,180 tt	1,227 tt	−3.8	−1.3	−0.7	−0.9
42	41	Cyclohexane	2.31	2.46	2,309 mp	2,461 mp	−6.2	8.3	2.2	2.4
43	44	Titanium dioxide	2.19	2.15	1,093 tt	1,077 tt	1.5	−2.2	3.4	3.7
44	43	Acetone	2.13	2.33	2,130 mp	2,331 mp	−8.6	−7.7	1.9	−0.1
45	45	Sodium silicate	1.79	1.76	894 tt	880 tt	1.6	5.6	2.5	1.5
46	46	Adipic acid	1.56	1.62	1,560 mp	1,620 mp	−3.7	−1.2	0.5	1.2
47	47	Sodium sulfate[n]	1.54	1.57	768 tt	786 tt	−2.3	4.1	−0.2	−3.6
48	48	Isopropyl alcohol	1.30	1.38	1,297 mp	1,380 mp	−6.1	−6.4	−0.1	−2.5
49	50	Calcium chloride[o]	1.29	1.38	644 tt	690 tt	−6.7	−13.9	−3.8	−3.5
50	49	Caprolactam	1.28	1.38	1,283 mp	1,380 mp	−7.0	5.5	3.0	3.3
TOTAL ORGANICS			225.67	220.05			2.6%	2.1%	4.3%	2.7%
TOTAL INORGANICS			407.77	412.82			−1.2%	2.0%	3.3%	0.7%
GRAND TOTAL			633.44	632.87			0.1%	2.1%	3.6%	1.4%

a Revised. **b** tt = thousands of tons, **bcf** = billions of cubic feet, **mp** = millions of pounds, **mg** = millions of gallons, **tmt** = thousands of metric tons. **c** Except refractory dolomite. **d** Natural and synthetic. **e** 100% basis. **f** Original solution. **g** Liquid and solid only. **h** Includes both acid and ester without double counting. **i** All grades. **j** 37% by weight. **k** K_2O basis. **l** Synthetic only. **m** Rubber grade. **n** High and low purity. **o** 75% basis, solid and liquid.

Top 50 chemicals production unchanged in 1991



unemployment levels. According to the Department of Labor, seasonally adjusted unemployment levels rose during 1991. However, other government data indicate prospects for a recovery. For instance, housing starts began to swing upward in 1991 from their depressed level of 1990, according to the Department of Commerce.

Other measures of the economy also show evidence of new vigor. The Federal Reserve reports that seasonally adjusted auto and light truck production rose 12% between the fourth quarter of 1990 and the fourth quarter of 1991. (However, production of all transportation equipment declined 2% between 1990 and 1991.) Textile mill production increased 6%, and paper and paper products were up 2% during the same period, according to the Federal Reserve. All of these are big markets for chemicals.

Although these industries are all customers of Top 50 products, shipments still lag. Chemical and allied products shipments were down about 1% between December 1990 and December 1991, according to the Commerce Department. Meanwhile, chemical producers' inventories increased about 2%. So while the chemical industry has kept up production to meet an anticipated recovery in demand, the commodity chemicals business has not recovered enough to take advantage of those inventories.

A broad segment of industry economists believe chemical exports were a major factor in the growth of commodity chemicals production in 1990. U.S. exports of all chemicals rose 7% to 38.9 billion lb in 1990 from their 1989 level, according to the Commerce Department. But despite an estimate by the Chemical Manufacturers Association (CMA) that sets U.S. chemical exports at $44 billion for 1991, production recorded in 1991 for the Top 50 chemicals hardly changed from the previous year. If CMA's estimate proves sound, then exports probably kept 1991 from becoming a year in which commodity volumes declined significantly.

Among the largest volume chemicals produced in the U.S., sulfuric acid remains at the top with total production of 86.6 billion lb, down nearly 2% from 1990. The decline follows an approximate 2% rise from the previous year. For 1991, nitrogen continues to rank a distant number two, with production at 57 billion lb, up slightly more than 1% from 1990. Nitrogen's rate of growth slowed from 1990 when production rose a little more than 4% compared with 1989.

Of the Top 50, the 29 organic chemicals accounted for some 36% of total production, compared with almost 35% in 1990. The combined organics production increased nearly 3% in 1991 from the previous year, after a 2% rise in 1990. Over the five-year period 1986–91, combined production of organic chemicals among the Top 50 increased an average of a little over 4% a year. Historically, though, their output has grown at a slower pace. Between 1981 and 1991, combined output of organic chemicals among the Top 50 grew at a compound annual rate of almost 3% a year.

While organic chemical production continued to grow in 1991, inorganic chemical production declined compared with the previous year. Combined output of inorganics on the list declined a bit more than 1% from the previous year, following a 2% rise in 1990. Over the five-year period from 1986–91, combined production of inorganic chemicals grew at an average annual rate of 3% a year. Like theorganics group, inorganics production historically has grown at a slow pace: less than 1% between 1981 and 1991.

For organic chemicals, 11 of the 29 on the Top 50 list posted production increases. Organic chemical growth in 1991 was led by propylene oxide, production of which rose nearly 13% from 1990 to an estimated 3.6 billion lb. As a result, propylene oxide production moved to 35th place on the 1991 list from 36th place in 1990. Styrene production also grew at a double-digit pace, up 12% in 1991 to 9 billion lb. Styrene's strong growth moved it to 21st place on the Top 50 list from 22nd place in the previous year. Ethylbenzene production increased slightly more than 10% from 1990 to 9.2 billion lb, but its 1991 rank was the same as in 1990: It continues to hold 20th place. Vinyl chloride production also grew 10% in 1991 to 11.7 billion lb, and occupies the same position (17th) on the list in 1991 as in 1990.

None of the organic chemicals regis-

tered double-digit declines in production in 1991. However, the organic chemical registering the biggest drop last year was acetone, down 9% to 2.1 billion lb. The decrease moved it to 44th place from 43rd in 1990. Caprolactam output fell 7% to 1.3 billion lb in 1991, slipping the chemical from 49th place in 1990 to 50th in 1991.

For inorganic chemicals, 10 of the 21 on the Top 50 list posted production increases, led by fertilizer materials potash, ammonium nitrate, and phosphoric acid, each with approximately a 3% increase in 1991. Potash production rose to 3.9 billion lb. Its position on the Top 50 in 1991, however, at 33rd was unchanged from the previous year. Ammonium nitrate production rose to 14.6 billion lb and output of phosphoric acid increased to 24.7 billion lb. Neither advanced on the list—ammonium nitrate remained in 14th place, and phosphoric acid remained seventh.

Three inorganic chemicals had production increases of around 2%: sodium silicate, sodium carbonate, and titanium dioxide. Sodium silicate output increased to 1.8 billion lb and stayed in 45th place in 1991. Sodium carbonate production rose to 20.5 billion lb, giving it the same position, 11th, among the Top 50 in 1991 as it held in 1990. Titanium dioxide production rose to 2.2 billion lb, moving it up to 43rd place in 1991 from 44th the previous year.

Half of the inorganics on the Top 50 list recorded production declines in 1991 compared with 1990. Taking the biggest fall was ammonium sulfate, production of which dropped a little over 12% to 4.5 billion lb. The decline slipped it to 31st on the list, down from 30th in 1990. Two inorganics experienced about a 7% drop in production in 1991: hydrochloric acid and calcium chloride. Hydrochloric acid production was 5.6 billion lb in 1991, but its position on the list, 27th, remained the same as in 1990. Calcium chloride production dropped to 1.3 billion lb in 1991, but it moved up a notch in the listing to 49th place in 1991 from 50th in 1990—only because caprolactam registered a bigger decline. Carbon black and carbon dioxide both saw production declines of 6% in 1990. Output fell to 2.7 billion and 9.8 billion lb, respectively. □

Plastics, synthetic fibers output rise

Overall U.S. production of commercial polymers, including plastics, synthetic fibers, and synthetic rubber, edged up a little over 1% in 1991 compared with 1990. As a result, production reached a new high last year: 62.8 billion lb. However, growth was not so strong as in 1990 when polymer output rose 5% over the previous year and totaled 62 billion lb.

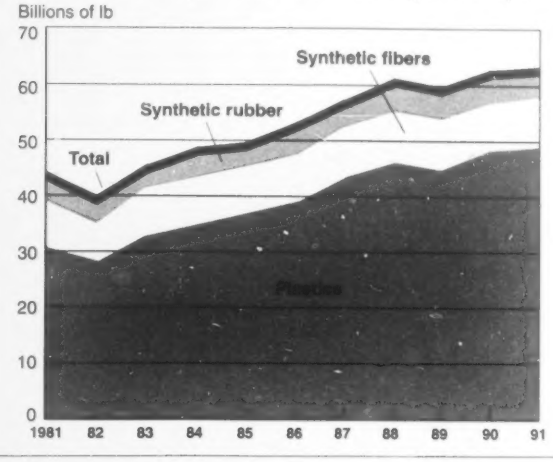
Plastics production, which accounts for more than three quarters of the polymer category's production total, led polymer growth in 1991 with a rise of nearly 2% to 49 billion lb. Synthetic fibers showed a production increase of less than 1% to almost 9 billion lb, and synthetic rubber output declined slightly more than 4% to just under 5 billion lb.

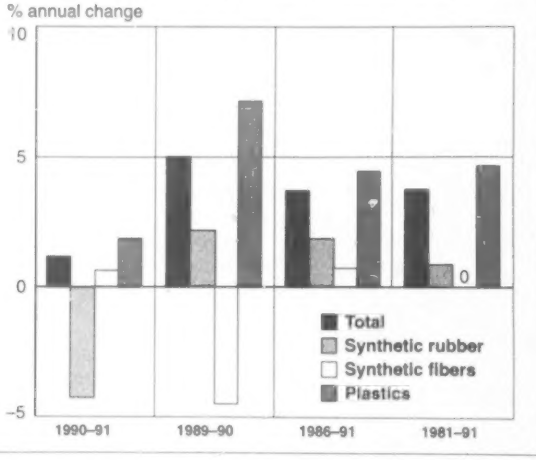
Production of thermoplastic resins grew a bit more than 3% to 43.3 billion lb in 1991 compared with 1990, following nearly 9% growth in 1990. Thermosetting resins production, however, dropped nearly 7% in 1991 to about 6 billion lb. This came after a decline of less than 1% in 1990.

Among the thermoplastics, high-density polyethylene production grew at an annual rate of almost 11% in 1991; it increased only 3% in 1990. Low-density polyethylene turned in the next best performance in 1991, with output up almost 4%, compared with a spectacular 15% rise in 1990. Production of polyvinyl chloride and copolymers rose slightly to just under 1% compared with a 7% increase in 1990. Polypropylene production hardly increased at all in 1991, compared with its 15% increase in 1990. For the second year in a row, polystyrene was the only thermoplastic to register a production decline, down slightly more than 1% in 1991 and nearly 2% in 1990.

In the thermosetting resins category, only unmodified epoxies recorded an increase in production, up more than 6% in 1991 following a 2% decline in 1990. Output of every other thermoset-

Plastics and synthetic fibers output rose, but synthetic rubber output declined in 1991





Total polymer production approached 63 billion lb in 1991

	Billions of lb		Common units				Average annual growth			
	1991	1990	1991	1990	1986	1981	1990–91	1989–90	1986–91	1981–91
PLASTICS (common units = millions of lb)										
Thermosetting resins[b]	**5.94**	**6.36**	**5,943**	**6,364**	**5,834**	**5,010**	**−6.6%**	**−0.6%**	**0.4%**	**1.7%**
Phenol and other tar acid resins	2.66	2.95	2,658	2,946	2,721	2,333	−9.8	2.3	−0.5	1.3
Urea resins	1.48	1.50	1,483	1,496	1,271	1,165	−0.9	1.4	3.1	2.4
Polyesters (unsaturated)	1.08	1.22	1,075	1,221	1,271	997	−12.0	−7.4	−3.3	0.8
Epoxies (unmodified)	0.53	0.50	531	499	398	336	6.4	−2.0	5.9	4.7
Melamine resins	0.20	0.20	196	202	173	179	−3.0	−9.0	2.5	0.9
Thermoplastic resins[b]	**43.26**	**41.91**	**43,255**	**41,912**	**33,569**	**25,671**	**3.2%**	**8.5%**	**5.2%**	**5.4%**
Low-density polyethylene	11.58	11.15	11,580	11,148	8,888	7,693	3.9	15.0	5.4	4.2
PVC and copolymers	9.17	9.10	9,168	9,096	7,256	5,707	0.8	7.3	4.8	4.9
High-density polyethylene	9.22	8.34	9,216	8,337	7,171	4,695	10.5	2.9	5.1	7.0
Polystyrene[a]	4.96	5.02	4,956	5,021	4,442	3,621	−1.3	−1.6	2.2	3.2
Polypropylene	8.34	8.31	8,335	8,310	5,812	3,955	0.3	14.8	7.5	7.7
TOTAL[b]	**49.20**	**48.28**	**49,198**	**48,276**	**39,403**	**30,681**	**1.9%**	**7.2%**	**4.5%**	**4.8%**
SYNTHETIC FIBERS (common units = millions of lb)										
Cellulosics[b]	**0.49**	**0.51**	**486**	**505**	**619**	**770**	**−3.8%**	**−12.9%**	**−4.7%**	**−4.5%**
Rayon[c]	0.27	0.30	273	299	404	509	−8.7	−17.6	−7.5	−6.0
Acetate[d]	0.21	0.21	213	206	215	261	3.4	−5.1	−0.2	−2.0
Noncellulosics[b]	**8.27**	**8.19**	**8,266**	**8,185**	**7,828**	**7,985**	**1.0%**	**−3.9%**	**1.1%**	**0.3%**
Polyester	3.41	3.20	3,410	3,195	3,305	4,176	6.7	−11.1	0.6	−2.0
Nylon[e]	2.54	2.66	2,537	2,662	2,514	2,333	−4.7	−2.8	0.2	0.8
Olefin[f]	1.87	1.82	1,865	1,822	1,393	785	2.4	11.2	6.0	9.0
Acrylic[g]	0.45	0.51	454	506	616	691	−10.3	−6.8	−5.9	−4.1
TOTAL[b]	**8.75**	**8.69**	**8,752**	**8,690**	**8,447**	**8,755**	**0.7%**	**−4.5%**	**0.7%**	**0 %**
SYNTHETIC RUBBER (common units = thousands of metric tons)										
Styrene-butadiene[h]	1.86	1.88	843	853	792	1,032	−1.2	−2.4	1.3	−2.0
Polybutadiene	0.92	0.91	415	412	336	342	0.7	0.2	4.3	2.0
Ethylene-propylene	0.51	0.59	232	266	230	178	−12.8	2.3	0.2	2.7
Nitrile	0.13	0.12	57	56	59	66	1.8	−18.8	−0.7	−1.5
Other[i]	1.47	1.60	668	725	596	404	−7.9	11.9	2.3	5.2
TOTAL[b]	**4.88**	**5.10**	**2,215**	**2,312**	**2,013**	**2,022**	**−4.2%**	**2.2%**	**1.9%**	**0.9%**
GRAND TOTAL	62.83	62.06					1.2%	5.0%	3.7%	3.7%

a No longer includes acrylonitrile-butadiene-styrene, or styrene acrylonitrile resins; historical data are restated. **b** Totals are for those products listed and may not add because of rounding. **c** Includes acetate tow beginning with 1985. **d** Includes diacetate and triacetate yarn, but does not include cigarette tow. Beginning with 1985, includes rayon yarn. **e** Excludes aramid after 1982. **f** Includes olefin film, olefin fiber, spun-bonded polypropylene, and vinyon. **g** Includes modacrylic. **h** Includes high-styrene latex. **i** Beginning with 1985, includes neoprene; historical data are restated. Also includes butyl; polyisoprene; chlorosulfonated polyethylene; polyisobutylene; and acrylo, fluoro, and silicone elastomers. **Sources:** Society of the Plastics Industry, Fiber Economics Bureau, Rubber Manufacturers Association, International Institute of Synthetic Rubber Producers

ting resin—unsaturated polyesters, phenol and other tar acid resins, urea resins, and melamine resins—fell in 1991. They were down 12%, 10%, 1%, and 3%, respectively. In 1990, unsaturated polyester production declined 7%, phenol and other tar acid resins increased 2%, urea resins rose 1%, and melamine resins fell 9%.

Synthetic fibers output made a marginal recovery in 1991 from 1990, reaching 8.75 billion lb. Synthetic fibers registered an almost 1% production rise, shaking off the severe impact the recession had in 1990 when their production dropped 5%. Production of cellulosic fibers continued to slip in 1991, but the nearly 4% decline for the group was not so severe as the almost 13% drop the previous year. Noncellulosics production rose 1%, and polyester led the group with a nearly 7% production rise in 1991 following a 11% drop in 1990.

Production of synthetic rubber decreased 4% to less than 5 billion lb in 1991 compared with 1990, according to the International Institute of Synthetic Rubber Producers (IISRP), Houston. Synthetic rubber data from 1989 and prior years came from the Rubber Manufacturers Association (RMA), Washington, D.C. RMA discontinued its annual report of synthetic rubber production in 1990. An RMA spokesman says the government discontinued its report of synthetic rubber production, and without it RMA has no reliable source against which to check its own data. Only IISRP felt confident enough to release U.S. production data gleaned from its own membership survey.

According to IISRP data, nitrile rubber and polybutadiene were the only synthetic rubbers to show any growth last year, with nitrile rubber output up almost 2% and polybutadiene up less than 1%. All others registered declines in production, with output of ethylene-propylene falling the most, 13%, in 1991 compared with 1990. Production of a group of miscellaneous polymers, including neoprene, butyl, and polyisoprene declined nearly 8% in 1991.

Marc Reisch

SPECIAL REPORT

CHEMICAL INDUSTRY OF THE FORMER U.S.S.R.

Jay K. Mitchell, PlanEcon Inc.

The chemical industry of the former Soviet Union is one of the largest in the world, producing more potash, chemical fertilizers, synthetic rubber, and ammonia than any other country in recent years. At the same time, this is one of the most backward and inefficient chemical industries among industrialized countries, producing mainly unsophisticated bulk products while having to import a large array of downstream products not produced in sufficient quantity or quality domestically.

Now, that chemical industry, like the country itself, is splitting into several new entities. Traditional relationships among factories in different republics (now becoming separate countries) have been strained or even totally cut off. The Novomoskovsk detergent factory, for example, one of Russia's largest and most modern detergent producers, located just outside Moscow, has been at a standstill for nearly a year owing to lack of feedstocks, which traditionally came from Kazakhstan. At the same time, each republic is faced with the difficult prospect of reforming and restructuring its economy—and chemical industry—at a time of economic chaos, hard-currency shortages, and growing domestic unrest in many regions.

Clearly the 1990s will be a period of difficult transition. What this transition period will look like, how fast restructuring will take place in the chemical industry, what the industry will look like in the year 2000, how the future prospects differ from republic to republic, and what business opportunities will emerge for Western chemical firms in coming years are some of the crucial issues to examine to understand what the immense changes mean for the chemical industry of the West in coming years.

Chemical industry in crisis

Like the entire economy of the former Soviet Union, the chemical industry finds itself in a recession so deep that it makes the current U.S. recession appear very minor in comparison. Only in the Great Depression of the 1930s have Western economies had any comparable experience. In 1991, the gross national product (GNP) of the former U.S.S.R. was down an estimated 15% from the previous year, industrial output fell nearly 10%, and gross output of chemicals dropped more than 10%. The rate of decline in all three cases accelerated over the course of last year, so that by the end of 1991 the GNP was declining at an annual rate of 20% or more. This year, the economies of the former Soviet republics are likely to experience even sharper declines in aggregate output, especially in those republics, such as Russia, that appear poised to begin radical economic restructuring.

The most important immediate problem for the chemical industry is declining production. Although the estimated 10% drop in gross output of chemicals by the former Soviet Union in 1991 was by far the largest drop in recent decades, it was merely the culmination of a gradual and steady slide.

ELOU-AVT high-octane gasoline plant of Moscow's oil refinery

Photo by TASS SOVFOTO

The average annual rate of growth of Soviet chemical output was a very impressive 10.5% during 1971–75; it subsequently fell to 5.7% during 1976–80, 4.9% during 1981–85, and only 2.8% during 1986–90. In 1990, Soviet chemical output fell a slight 0.9%. Such a massive deterioration over the past two decades has no equivalent in the West, although many East European countries have suffered similar or even greater output declines in recent years.

The deterioration in Soviet chemical performance is clearly reflected in declining production of many major chemical products. Between 1986 and 1990, output of the following chemicals either stagnated or declined: soda ash (3.5% average annual decline); fertilizers (down 2.3%); white pigments (down 2.2%); caustic soda (down 2.0%); ammonia (down 1.7%); benzene (down 0.7%); sulfuric acid (down 0.5%); chemical fibers, methanol, and synthetic rubber (all virtually unchanged); dyes, tires, and plastics (less than 1% average annual growth); and paints (only 1.4% average annual growth). Thus, even those sectors in which the Soviets were leading world producers, such as fertilizers and synthetic rubber, suffered from declining or stagnant output in the late 1980s.

Another major problem of the former Soviet chemical industry is its relatively unsophisticated output. In a period when the worldwide chemical industry is increasingly specializing in niche products, the Soviet portion of that industry has remained largely based on bulk products. In 1988, for example, nearly half (44%) of total Soviet chemical output consisted of bulk inorganic and organic products, including fertilizers. Downstream chemical sectors, such as pharmaceuticals, paints, detergents, and other small-batch chemicals, are highly undeveloped in the former U.S.S.R. As an illustration, pharmaceuticals, soaps, detergents, perfumes, and cosmetics accounted for only about 12% of total Soviet chemical production in 1990, about half of their 24% share of West European chemical output.

Within virtually every chemical sector, the former Soviets

About the cover

The Nizhnekamsk Petrochemical Combine, shown on the cover, is located in the Volga region of Russia and is the second largest chemical complex in that republic. Nizhnekamsk is Russia's largest producer of ethylene (with capacity of 450,000 tons per year) and also produces propylene, benzene, butadiene, ethylbenzene, ethylene glycol, and other petrochemicals. Most of these units date from the 1970s. The Nizhnekamsk complex is also notable because it was one of the first Soviet chemical firms to successfully start up new production capacity under a joint venture with a Western firm: 60,000 tons per year of ethylene glycol capacity came on stream in 1990 as part of a joint venture with MRH of Germany. There is also an oil refinery at Nizhnekamsk that began operating in 1979.

usually produce older, obsolete products: 40% of their plastics output still consists of thermosets, more than one third of chemical fiber output is in cellulosics, oil-based paints still account for more than one third of paint production whereas output of water-based paints remains very small, and general-purpose rubbers still account for more than 80% of synthetic rubber output.

This unsophisticated balance of chemical products has been reflected in Soviet chemical trade in recent years. About two thirds of Soviet chemical exports in 1990 consisted of bulk organic and inorganic chemicals, including fertilizers and chemical raw materials. Moreover, the fraction of chemical exports coming from these categories increased during the 1980s, as the Soviets sought to export almost anything that could earn them much-needed hard currency. This rush to export, and the resulting record export levels for many bulk chemicals, in fact, brought the Soviets several accusations of dumping such products as urea, permanganates, and isobutyl alcohol on world markets.

Imports of downstream products such as paints, dyes, pharmaceuticals, soaps, detergents, and cosmetics accounted for nearly two thirds of total Soviet chemical imports in 1990, up from a 40% share in 1980. Overall, the U.S.S.R. was a large net importer of chemicals during the 1980s, with the deficit rising from about $1 billion in 1980 to a peak of $2.4 billion in 1989. Even these rising chemical imports, however, many of which were chemical intermediates imported to supply the domestic chemical industry, could not stop the slowdown in the growth of the Soviet chemical industry in the 1980s.

A major reason for this disappointing performance has been lack of adequate investment in chemicals by the government in recent years. Between 1980 and 1990, investment in the Soviet chemical industry fell 13% in constant-value terms, even though investment in total industry grew 57% over the same period. Thus, the share of chemicals in total Soviet industrial investment fell from 8.4% in 1980 to 4.7% in 1990. Investment in chemicals was sacrificed during the 1980s to free up resources for machine building and energy production, which saw their combined share in industrial investment rise to 62% in 1990.

The quality of chemical investment also declined considerably over the decade. During the early and mid-1980s, a serious attempt was made to move away from purchasing Western equipment and technology for new Soviet production facilities and to rely instead on suppliers in the U.S.S.R. or Eastern Europe. The result of this attempt was to slow what was already a slow pace of bringing new plants on stream and up to full operating capacity. Declining investment resources were channeled into a few priority sectors, which included plastics and certain bulk inorganic and organic chemicals for export. Consequently, other sectors—notably chemical fibers, paints, dyes, pharmaceuticals, and synthetic rubber—suffered from gross underinvestment during the 1980s.

A second major factor in the deterioration of the Soviet chemical industry has been the nature of the industry itself. On average, Soviet chemical plants are much larger than those in the West, employing thousands of workers. The largest chemical plant in the former U.S.S.R., the Mogilev Chemical Fiber Production Association in Belarus, employs more than 20,000 people. Fifteen chemical plants in the former U.S.S.R. each have more than 10,000 workers, and 79 plants (47 of which are in Russia alone) each employ more than 5000 workers.

But more workers do not necessarily mean higher output. Average worker productivity in the Soviet chemical industry in the late 1980s was only one third that of the U.S. and a mere one fourth that of the former West Germany. Thus, although the former Soviet and U.S. chemical industries employ almost the same number of workers (about 2 million in both cases), the total value of U.S. chemical output each year has been about three times that of the U.S.S.R. Part of this difference comes about because Soviet chemical complexes, like other industrial facilities in the former U.S.S.R., were often responsible for a whole range of functions not considered part of factory work in the West. These included providing employees with food, housing, schooling, and vacations. This practice is slowly changing, but will not be eliminated overnight.

Past Stalinist economic policies held that large factories would help industrialize the country faster and lead to increased economies of scale. The legacy of these policies is a large number of massive complexes in desperate need of restructuring. In many cases, existing complexes must be split into several smaller units before any investor—domestic or foreign—is likely to be interested in them.

Another problem is the need to convert chemical plants formerly in the defense sector to civilian use. Although this problem is more severe in other sectors of industry, such as machinery, it is still significant for chemicals. Some chemical plants produced their entire output for the military; others, though also producing for other uses, still counted on the military to purchase much of their production. Now, as demand by the military collapses in most of the former U.S.S.R., these chemical facilities find that a major market for their output has been eliminated almost overnight. They must find new markets for existing production (an easier task in the case of chemicals than for most machinery), change their output profile to attract buyers for their products, or face going out of business.

Reforms appear imminent

The major positive accomplishment of the failed August 1991 coup in the Soviet Union was rapid dismemberment of the old economic system. Mikhail Gorbachev, although a true reformer in the spheres of domestic politics and foreign policy, was a dismal failure on the economic front. Despite his promises to reform the U.S.S.R.'s economy and several real opportunities to do so, the former Soviet leader hesitated every time it came to actually implementing reforms. Essentially, Gorbachev managed to dismantle much of the old centrally administered command economy without providing a viable replacement, such as a market system. The result was disaster for both the Soviet economy and Gorbachev's own political career.

Now that authority has passed to the individual republics, the outlook for economic reform is much improved. The Baltics are moving ahead rapidly to introduce a market system. And many republics, including the second largest, Ukraine, intend to introduce their own currencies. Russia, led by Boris Yeltsin, is also attempting a rapid reform of its economy, having raised (but not totally decontrolled) prices in early January.

The key to reform in many of the former Soviet republics is what happens in Russia. If Russia proceeds with its already-declared plans to charge other republics world market prices for the raw materials it supplies to them (including oil and gas that serve as feedstocks for petrochemicals), then those republics will be strongly compelled to free prices or face rising subsidies. On the other hand, if Russian reform efforts stall or become bogged down by popular opposition (such as that witnessed following the January price rises), then it will be more difficult for the other republics to follow a fast track on reform. The huge Russian market of nearly 150 million consumers has been the most important one for nearly every former Soviet republic, and it is likely to remain so for the near future.

The economic reform process will be difficult throughout the former Soviet Union. As the East European economies have shown, economic restructuring leads to short-term production declines, rather than increases, as older, less efficient production units are closed down permanently or temporarily for revamping. In the case of chemicals, decades of inadequate and poorly utilized investment have rendered entire sectors of production—including p ints and chemical fibers—uncompetitive in world markets. Restructuring these sectors will be especially painful. For other chemical sectors, economic restructuring will lead to a fall in short-term demand, which will hurt output. In particular, demand for bulk fertilizers will decline because of price liberalization, and chemical fiber demand is likely to drop as well if textiles become one of the industrial sectors hardest hit by the recession, as happened in Eastern Europe.

Despite these drawbacks, economic reforms are likely to proceed in the majority of the former Soviet republics, including all-important Russia, if only because there is no viable alternative. The failed August coup drove the nails into the coffin of the old economic system. And the reform process will be aided by the West. Assistance from both Western governments and multilateral institutions like the World Bank and International Monetary Fund will help to keep the reforms on track.

However, it likely will be several years before these reforms have a positive impact on the chemical industry. Declines in overall chemical output will continue through the mid-1990s. For example, I predict chemical output of the former U.S.S.R. in 1995 will be a full 16% below the 1990 level because of the closure of many factories. Full-fledged recovery in chemical output is not really feasible, given the depth of restructuring required in Russia and other reform-minded republics, before the late 1990s. Thus, the recession in the former Soviet chemical industry will be a long one.

Profile for 2000

Once economic recovery begins in the late 1990s, it likely will gain momentum swiftly. For chemicals, consumer-oriented product sectors such as plastics, organic intermediates, pharmaceuticals, soaps, and detergents will drive the recovery. Just as these sectors were largely neglected in past

Commonwealth's largest chemical plants are in Russia and Belarus

Plant name	Republic
1. Mogilev Chemical Fiber Production Association	Belarus
2. Kirovsk Apatite Production Association	Russia
3. Nizhnekamsk Petrochemical Combine	Russia
4. Soligorsk "Belarusalkaliy" Production Association	Belarus
5. St. Petersburg Technical Rubber Production Works	Russia
6. Bobruysk Tire Production Association	Belarus
7. Kalush "Khlorvinil" Production Association	Ukraine
8. Balakovo Chemical Fiber Production Association	Russia
9. Nizhnekamsk Tire Production Association	Russia
10. Zhanatas "Karatau" Production Association	Kazakhstan

[a] Part of the former U.S.S.R., but not part of the new Commonwealth of Independent States

Soviet industrial strategies, the new market environment will create conditions for them to flourish. Western investment could become particularly significant in all these sectors.

By the year 2000, the combined chemical industries of the former Soviet republics will be smaller and more productive than the Soviet chemical industry was. In particular, less phosphorus, sulfuric acid, calcium carbide, mineral fertilizers, chemical fibers, and paints will be produced, and production of numerous other chemicals will stagnate or rise only modestly. This slowdown will be brought on by the large-scale shutdown of older plants that are obsolete, inefficient, polluting, or all three. Chemical employment also will shrink during the 1990s as restructuring and modernization make at least one third of current chemical jobs redundant. Thus, in 2000, the chemical industry of the post-Soviet republics will employ no more than 1.2 million to 1.3 million workers, compared with the current 1.8 million to 1.9 million.

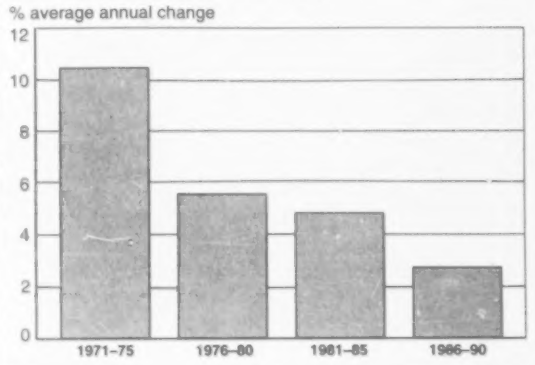
But although production and employment in chemicals will contract, the value of chemicals produced will actually rise. Whereas total Soviet output of chemicals and petrochemicals was estimated by PlanEcon in 1990 at $85 billion (at world market prices), by 2000 output could be worth $100 billion or more. Much of the existing capacity that must be shut down in coming years represents units that produce lower quality and lower value products and that probably should have been closed long ago. Specifically, chemical fiber capacity to be closed in coming years will consist largely of cellulosic fiber units, which are inefficient and heavily polluting. Fertilizer units likely to be decommissioned include bulk single-nutrient products, which have added to soil and water pollution problems in recent decades, rather than high-nutrient complex and compound substances. Thus, the loss to the value of chemical output by the former Soviet republics from these plant closures is not so great as it might seem at first glance.

Moreover, a wave of modernization during the second half of the 1990s will result in building new units that will add substantial capacity in higher value-added products, such as small-batch products, consumer chemicals, and plastics. In small-batch chemicals, new capacity to make water-based paints, synthetic dyes, gasoline and fuel additives, plastics additives, rubber chemicals, environmentally friendly plant pesticides and microbiological products is expected to be built during the late 1990s.

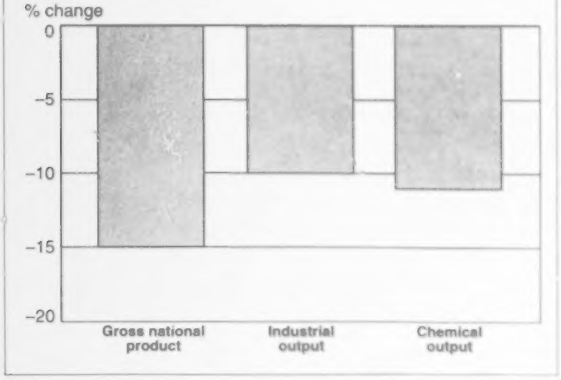
In all of these areas, the current capacity in most republics is too small and the likely future market too great to avoid building new units. For example, environmental concerns will probably compel the republics to begin converting to unleaded gasoline during the 1990s. At the same time, more private cars will raise demand for various gasoline additives and car-care products. Some of this demand could be met through imports, but the very large potential markets in Russia, Ukraine, and other republics will almost certainly lead to domestic production of many of these products, including some production with the assistance of Western investors. Similarly, the need for manufactured goods from Russia, Ukraine, Kazakhstan, and other republics to compete on world markets will require much improved paints. In the near-term, paint imports will rise, but eventually domestic production also will rise to meet part of the demand increase.

Recent extremely high levels of consumer chemical imports point to attractive future production opportunities. The U.S.S.R. imported an average of more than $1 billion annually of pharmaceuticals, soaps, and detergents from the West during 1988–90, a period of extremely tight hard-currency restrictions. This unprecedented high level occurred because of grave domestic shortages, and points to a huge unsatisfied demand there. Thus, just as has been occurring in Eastern Europe, consumer chemicals could become one of the most popular chemical sectors for Western investment. In particular, the massive size of the Russian market (nearly 150 million consumers) as well as Ukraine (more than 50 million consumers) provides potential sales opportunities unmatched by any East European country and superior to virtually any other emerging market today. Already, Ukraine has been the target of a number of small-scale investments involving consumer chemicals, suggesting that activity could take off there even faster than in Russia.

Slower growth for Soviet chemical industry began in late 1970s



U.S.S.R.'s final year (1991) was a bad one for the economy



Current low per capita levels of plastics production and consumption point to immense growth potential. At present, per capita plastics consumption in all the former Soviet republics is only about 20 kg per year, about one fifth of the U.S. level. Modernization and economic restructuring will raise plastics demand during the 1990s, as plastics replace such materials as wood and metals in applications that include construction materials and packaging. Plastics production capacity is already being expanded through a number of ventures involving Western capital, including one in which the U.S. chemical firm Huntsman (Salt Lake City, Utah) plans to build a polystyrene plant in Ukraine, another in which Germany's Linde will modernize and expand an existing polyethylene facility at Novokuybyshevsk in Russia, and the huge Wespec venture with the U.S. firm Combustion Engineering that will build sizable polypropylene capacity at Tobolsk in Russia.

Despite these expected gains, however, the chemical industry in the former Soviet republics in 2000 will still be based mainly on bulk chemicals. Output of basic inorganic chemicals, such as caustic soda and soda ash; organic chemicals, such as ethylene and methanol; and mineral fertilizers, such as urea, will still predominate. Such continued emphasis on bulk products is not necessarily bad, given the former U.S.S.R.'s vast resources of oil and gas for petrochemical synthesis and of chemical raw materials for making fertilizers and other bulk inorganic chemicals. Indeed, the comparative advantage of the chemical industries of Russia, Kazakhstan, and certain other former Soviet republics will remain in upstream output.

And the market for many of these bulk chemicals could be quite favorable in the late 1990s and beyond. With Eastern Europe expected to sharply curtail output of many bulk chemicals, including single-nutrient fertilizers, because of much higher costs of oil and gas feedstocks as well as other raw materials, Russia and other former Soviet republics could find growing demand for their basic chemicals there. Western Europe, too, may be a good market for certain of Russia's traditional bulk exports. For example, world methanol supplies are expected to tighten in coming years, making Russian exports potentially quite lucrative. Soviet methanol exports averaged nearly 1 million metric tons per year in the late 1980s, most of which came from Russia. This made the U.S.S.R. the leading world exporter of methanol during the past decade.

Production growth slowed in late 1980s for most chemical product areas in former U.S.S.R.

Thousands of tons, except as noted	Production			% average annual change		
	1980	1985	1990	1981–90	1981–85	1986–90
BASIC INORGANIC CHEMICALS						
Ammonia, synthetic	16,732	22,167	22,208	2.9%	5.8%	0 %
Caustic soda	2,755	3,056	2,973	0.8	2.1	−0.5
Sulfuric acid	23,033	26,037	27,300	1.7	2.5	1.0
Soda ash	4,661	4,916	4,359	−0.7	1.1	−2.4
AGRICULTURAL CHEMICALS						
Mineral fertilizers, 100% nutrient	24,767	33,194	31,676	2.5	6.0	−0.9
Nitrogen, 100% N	10,241	14,223	13,208	2.6	6.8	−1.5
Phosphate, 100% P_2O_5	6,455	8,596	9,431	3.9	5.9	1.9
Potassium, 100% K_2O	8,071	10,375	9,037	1.1	5.2	−2.7
Plant pesticides, 100% active	282	6,137	205	−3.1	85.2	−49.3
PLASTICS AND SYNTHETIC RESINS	3,637	5,019	5,536	4.3	6.7	2.0
Polyethylene	278	559	642	8.7	15.0	2.8
Polypropylene	32	93	127	14.8	24.0	6.3
Polystyrene	247	466	515	7.6	13.6	2.0
Polyvinyl chloride	398	455	606	4.3	2.7	5.9
CHEMICAL FIBERS	1,176	1,394	1,477	2.3	3.5	1.2
Artificial fibers, cellulosics	606	605	522	−1.5	0	−2.9
Synthetic fibers, noncellulosics	570	789	955	5.3	6.7	3.9
SMALL-BATCH CHEMICALS						
Paints and varnishes	2,883	3,315	3,543	2.1	2.8	1.3
Dyes, synthetic (tons)	81,033	73,355	83,959	0.4	−2.0	2.7
Detergents, synthetic	1,012	1,150	1,503	4.0	2.6	5.5
Soap, 60% basis	1,045	976	1,137	0.9	−1.3	3.1
BASIC ORGANIC SYNTHESIS PRODUCTS						
Olefins						
Ethylene	1,773	2,667	3,065	5.6	8.5	2.8
Propylene	824	1,177	1,366	5.2	7.4	3.0
Aromatics						
Benzene	1,644	1,971	2,080	2.4	3.7	1.1
Toluene	1,202	1,023	1,027	−1.6	−3.2	0.1
Xylenes	459	937	943	7.5	15.3	0.1
Alcohols						
Butanols	205	300	343	5.3	7.9	2.7
Ethanol	306	276	229	−2.9	−2.0	−3.7
Methanol	1,900	2,850	3,233	5.5	8.4	2.6
SYNTHETIC RUBBER	2,050	2,125	2,350	1.4	0.7	2.0

Source: December 1991 PlanEcon *Soviet Chemical Review*

Prospects differ for republics

The republics of the former Soviet Union have vastly different chemical industries, ranging from Russia's huge industry, which produced chemicals and petrochemicals with an estimated value of $55 billion in 1990, to Moldova's, which produced less than $200 million the same year. Areas of emphasis also differ, from bulk petrochemicals in Russia and Kazakhstan to agricultural chemicals in Ukraine and

Moldova, chemical fibers in Belarus, and downstream products in the Baltics. Thus, any discussion of the future for these republics' chemical industry must consider prospects for individual republics.

Russia. The Russian chemical industry, with an estimated $55 billion worth of chemical and petrochemical production in 1990, is roughly the size of Italy's chemical industry. But Russia has more than twice the population of Italy, making its per capita chemical production less than that of many East European countries, including Czechoslovakia and Hungary. Its chemical industry includes more than 600 plants employing nearly 1 million workers (977,000 in 1989). Russia's real strength as a chemical producer lies in the republic's vast natural resources. Abundant oil and gas reserves make it a huge petrochemical producer, and vast deposits of chemical raw materials, such as sulfur and phosphorus, feed a massive inorganics and fertilizer sector. Russia produces just under two thirds of the total value of chemicals from the former U.S.S.R., and its share in production of certain bulk products is even higher: caustic soda, soda ash, and polyvinyl chloride (about 75%); polypropylene, xylenes, and methanol (more than 80%); and acetone, phenol, synthetic rubber, and high-density polyethylene (more than 90%).

Russia's small-batch and consumer-oriented chemical production is its major weakness. Production facilities for paints and dyes are antiquated, and at least half of existing capacity should be closed down. Despite recent attempts to boost the quality and quantity of output of pharmaceuticals, soaps, and detergents, the Russian market is one of the most undersupplied with these products.

Chemical fibers are another weak aspect of Russian chemical production. Although Russia accounts for nearly two thirds of total cellulosic fiber production in the former Soviet republics, its share in more modern synthetic fibers is less than two fifths. In particular, Russia produces very little polyester, acrylic, or polypropylene fiber.

Russia's chemical industry has very good prospects for the 1990s and beyond, thanks to foreign investment. Investment will begin as a ripple in the next year or two, but by the end of the decade, it is expected to have become a tidal wave. Russia's chemical industry is one of the few in Europe with ready access to a wide range of relatively cheap, abundant, and domestically produced chemical feedstocks. Russia's enormous market for consumer chemicals—it has more than double the population of the U.K., France, or Italy—is likely to attract foreign investment in areas such as soaps, detergents, and pharmaceuticals. And there's good potential for growth in other spheres as well, including plastics, noncellulosic fibers, and paints.

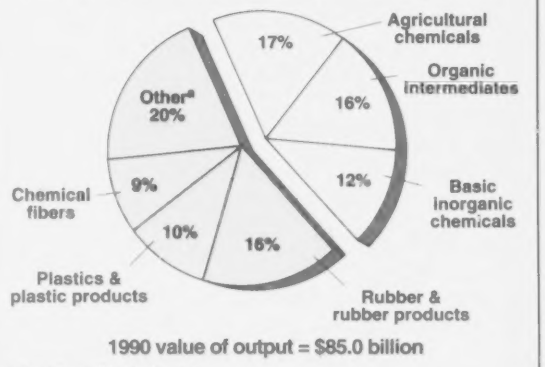
Russia's chemical industry is not without challenges, however, which include an underdeveloped and overtaxed transport and telecommunications network. These problems are especially acute in remote areas, such as Siberia, where a large portion of foreign investment in chemicals this decade is likely to be headed. The country's immense potential as a chemical producer and exporter, however, ensures sizable foreign investment that will help to upgrade and modernize existing plants as well as build entirely new facilities.

Ukraine. The second largest republic of the former Soviet Union is also its second largest chemical producer, with chemical production in 1990 valued at an estimated $15 billion. In per capita chemical output, though, Ukraine not only lags behind most Western countries, but also the republics of Russia and Belarus. Over the past 20 years, when new chemical and petrochemical complexes were being built in Russia, Belarus, and Kazakhstan, relatively little new capacity has been commissioned in Ukraine.

In contrast to Russia and Kazakhstan, Ukraine does not have the abundant oil and gas reserves needed to drive a vibrant petrochemical industry. Rather, its petrochemical sector is based largely on coke chemicals. This capacity is outmoded and many units will be shut down in coming years. Ukrainian petrochemical producers face the unhappy prospect of paying several times more for feedstocks once the prices Ukraine pays for Russian and Kazakh oil and gas rise to world market levels.

The Ukrainian chemical industry consists of 208 plants employing some 295,000 workers. As in Russia, production is largely in bulk, rather than downstream, products. Unlike

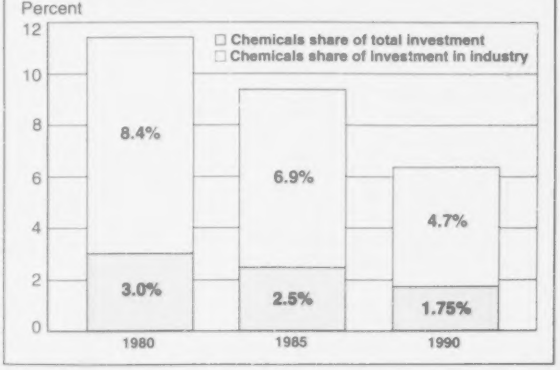
Nearly half of 1990 Soviet chemical output was in agrochemicals, organics, inorganics



1990 value of output = $85.0 billion

a Primarily small-batch chemicals.

Chemical industry has been losing its share of Soviet industrial investment



Russia, however, Ukraine's chemical industry does not have easy access to cheap and abundant raw materials for inorganic and organic chemical synthesis. Thus, Ukrainian chemical managers will need to shift at least a portion of production further downstream in order to remain profitable. The country's current production profile suggests just how difficult this shift might be. Ukraine accounted for only 14% of total Soviet plastics output in 1989, and its share of chemical fiber production was only 12%.

Recently, however, Western investors have expressed interest in Ukrainian consumer chemicals and plant pesticides, and these two spheres hold promise for future development. Consumer chemicals look promising because of Ukraine's large and geographically concentrated market and the republic's closer proximity to Europe than Russia's market. Plant pesticides invite Western investors because Ukraine is one of the most productive agricultural regions of the former Soviet republics. It is also a major producer of dyes, accounting for more than one third of Soviet production in 1989 and having some of the more modern dye factories in the republics. Almost all of the former Soviet Union's titanium dioxide was produced in Ukraine. Thus, the Ukrainian chemical industry has serious challenges ahead, but shows some potential to move production further downstream.

Belarus. Although Belarus (formerly Byelorussia) is only the fifth largest former Soviet republic in terms of population, it is the third largest chemical producer. This republic of 10 million people produced an estimated $5 billion in chemicals in 1990. Thus, Belarus produced an estimated $490 of chemicals per capita in 1990, making it by far the most productive of the former Soviet republics by this measure.

Belarus' chemical industry enjoys certain other advantages as well. It is among the most modern of all the republics, producing plastics and plastics products, synthetic fibers, organic intermediates for fiber manufacture, and potassium fertilizers. Belarus accounted for more than 80% of Soviet polyester fiber output in the late 1980s, and its share of acrylic fiber production was more than 50%. Also, Belarus' 47 chemical plants, which employ about 100,000 people, earned 50% greater profits in 1990 than the average Soviet chemical firm.

Still, the Belarus chemical industry has several weaknesses. Most important, it is highly dependent on imported oil and gas feedstocks, which, in the past, came from Russia. Russia now appears poised to charge Belarus and the other former Soviet republics world market prices for its exports. Such a change would hit the industry hard, as it has the chemical industries of many East European countries during the past two years.

Paint output in Belarus is minimal, and dye production is practically nonexistent. Output of plant pesticides is also minimal, even though agriculture remains an important sector of the Belarus economy. Belarus' share of both detergents and pharmaceuticals was below its share in total Soviet chemical output in 1990. These consumer chemicals aren't likely to attract Western investors, given the relatively small size of the domestic market, compared with those of neighboring Russia, Ukraine, and even Poland.

Perhaps Belarus' greatest disadvantage, however, is that this republic is one of the lesser-known in the West. The recent decision to place the capital of the newly formed Commonwealth of Independent States in Minsk has helped to put Belarus "on the map," but it will take aggressive efforts from the republic's leaders to attract sizable Western investment to what is one of the most modern chemical industries in the former U.S.S.R.

Kazakhstan. Although it has a larger population than Belarus, Kazakhstan has barely half the chemical output (valued at an estimated $2.6 billion in 1990). Kazakhstan has 39 chemical plants employing a total of about 83,000 people. Like Belarus, Kazakhstan has a relatively modern chemical industry, which began when several plants were evacuated here from Russia during World War II. However, the republic's chemical facilities are relatively unprofitable and very heavy consumers of energy—the average chemical plant in Kazakhstan consumed three times the amount of electricity used by the average Soviet plant in 1990. Energy-intensive products such as inorganic chemicals and bulk fertilizers figure prominently in Kazakhstan's chemical production; other major products include chemical raw materials, rubber, and rubber products.

The future of Kazakhstan's chemical industry lies in petrochemical synthesis and sour-gas recovery of sulfur. Large oil and gas reserves make this republic a natural candidate for petrochemical complexes, and several attempts have been made to build such complexes in recent years with the

Ten largest chemical complexes in former U.S.S.R. each employ more than 11,000 workers

No.	City and complex name	Republic	Number of workers	Major products
1	Mogilev Chemical Fiber Production Association	Belarus	20,320	Chemical fibers
2	Kirovsk Apatite Production Association	Russia	17,780	Chemical raw materials
3	Nizhnekamsk Petrochemical Combine	Russia	16,190	Organic synthesis chemicals
4	Soligorsk "Belarusalkaliy" Production Association	Belarus	13,420	Chemical raw materials
5	St. Petersburg Technical Rubber Production Works	Russia	13,350	Rubber products
6	Bobruysk Tire Production Association	Belarus	13,230	Rubber products (tires)
7	Kalush "Khlorvinil" Production Association	Ukraine	13,090	Organic synthesis chemicals
8	Balakovo Chemical Fiber Production Association	Russia	12,730	Chemical fibers
9	Nizhnekamsk Tire Production Association	Russia	12,040	Rubber products (tires)
10	Zhanatas "Karatau" Production Association	Kazakhstan	11,160	Chemical raw materials

help of Western investors, including an ill-fated project at Tenghiz involving Occidental Petroleum and other Western firms. Most of these projects were stalled or even canceled after Western investors became disillusioned by bureaucratic hurdles and logistical problems, which include lack of storage and transport facilities, lack of adequate housing and services for prospective employees, and poor telecommunications services. To attract foreign investment and support large new petrochemical capacity, Kazakhstan needs to build up its infrastructure and transportation facilities.

Perhaps more so than for any other republic, Kazakhstan's future depends on its relations with Russia. A huge number of Russians live in Kazakhstan, and Russian President Yeltsin has already hinted at possible border disputes between the two republics. Further possibility of conflict might come should Kazakhstan decide to compete directly with Russian Siberia for large-scale Western investment in petrochemicals. Given these factors, Kazakhstan's chemical industry is likely to remain relatively undeveloped through the late 1990s. But the potential remains for considerable development after 2000.

Transcaucasus. The three Transcaucasus republics—Armenia, Azerbaijan, and Georgia—are highly unstable politically, and this spells trouble for their chemical industries in coming years. The war between Armenia and Azerbaijan, combined with civil war in Georgia, threaten to make this region into another Lebanon. These republics' chemical industries are fairly small—together, the three produced an estimated $3.1 billion in chemicals in 1990. Output tends to be in bulk chemicals in Azerbaijan, including chlor-alkalies, sulfuric acid, ethylene, propylene, and synthetic rubber. Georgia's output is more downstream-oriented in products such as polypropylene fibers, detergents, paints, and pharmaceuticals. Armenia makes both bulk and downstream products, including nitrogen fertilizers and bulk organic chemicals, but also plastics and plastics products, pharmaceuticals, and rubber and rubber products.

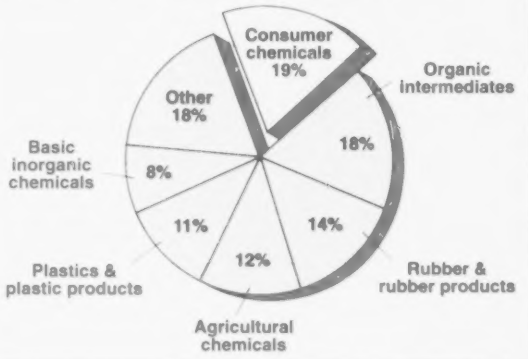
These three republics together have 93 chemical plants, about half of them in Georgia, employing about 66,500 people. Unless a peaceful resolution can be found to both Georgia's bloody civil war and the hostilities between Armenia and Azerbaijan, it will be hard to modernize and upgrade chemical facilities or to attract Western investment.

Mistakes of the past also cloud the future of chemicals in the Transcaucasus. In Armenia, for instance, the highly polluting Nairit rubber facility, located in a suburb of Yerevan, Armenia's capital, has helped to spawn a vocal grass-roots "green" movement that is expected to act as a constraint on future development of chemicals in that republic. Such movements have sprung up all over the former Soviet republics in recent years and have gained growing influence with politicians.

Baltics. The three Baltic republics of Estonia, Latvia, and Lithuania have some of the most downstream-oriented chemical industries in any of the republics. Unlike most of the republics, the Baltic republics have not become members of the Commonwealth of Independent States and are expected to pursue their own path to full economic and political independence.

These three republics, containing only about 8 million people, produced an estimated $2 billion worth of chemicals in 1990. The 46 chemical plants located in the Baltics, employing about 52,000 people, produce mainly plastic products, pharmaceuticals, rubber products, and other consumer-oriented products (such as soaps, detergents, perfumes, and cosmetics). Bulk chemicals produced in the Baltics include inorganic acids (nitric and sulfuric), fertilizers (nitrogen and phosphate), and methanol and calcium carbide (both in Lithuania).

Consumer chemicals will be largest sector of republics' chemical output by 2000



Notably absent from Baltic chemical output are primary plastics, and the secondary processors located there must import polymers either from other former Soviet republics or from abroad. This interdependence has, until now, been imposed on these republics by the central government in Moscow. It is a legacy of the Stalinist economic model, which sought to forcibly integrate the economies of the Baltic republics with that of the remainder of the U.S.S.R. following their annexation in 1940.

The outlook for the chemical industry in the Baltics is mixed. On the one hand, these three republics already produce an impressive array of downstream products, and their chemical facilities are, on average, more modern and efficient than those in other former Soviet republics. But the chemical industry in the Baltics faces several challenges. First, it will be hit particularly hard by the need to pay world market prices for oil and gas feedstocks, since domestic resources are minimal. Lithuania, in particular, has a sizable refinery and petrochemical complex that has depended on cheap Russian oil in the past. Second, the rapid departure of the Baltics from the union has left relations somewhat strained with Russia, which has been a significant market for their chemical output. And third, several plants face closure: The calcium carbide facility at Kaunas in Lithuania and oil-shale-based organic chemical units in Estonia are old, inefficient, and highly polluting.

Central Asia. Although the four remaining republics in Central Asia—Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan (the fifth, Kazakhstan, has been discussed separately)—accounted for more than 10% of the population of the former Soviet Union, their share in Soviet chemical output in 1990 was only 2.4%. This highly undeveloped region has a burgeoning population, but only produced an esti-

mated $2 billion worth of chemicals in 1990. Almost all of this chemical output is in Uzbekistan, with the other three republics having minuscule chemical industries. These four republics have 57 of the most unprofitable chemical plants in the former U.S.S.R., employing about 60,000 people. Located there are several energy-intensive complexes for producing bulk inorganic chemicals and fertilizers, even though these republics have little in the way of domestic energy resources.

This legacy of past inappropriate industrialization policies imposed by a central government in Moscow will not necessarily be solved by independence. Indeed, one unfortunate legacy—environmental degradation caused not only by chemical production but also by faulty irrigation practices and excessive use of fertilizers—will remain for a long time. The outlook for this region's chemical industry is poor, given its unfavorable economic and political prospects and lack of attractive investment prospects for Western investors. And although past economic policies imposed by Moscow were flawed, these republics' chemical industries probably still received more investment resources than they would have been able to pull together had they been independent entities.

Moldova. Tucked in the European portion of the former Soviet Union, tiny Moldova (formerly Moldavia) with just 4 million people has an equally tiny chemical industry. Estimated value of chemical output in 1990 by the republic's 17 plants, employing about 4400 people, was less than $200 million. The major spheres of activity are downstream products—detergents, paints, and pharmaceuticals. But output is too small to be considered impressive. Future prospects for Moldova's chemical industry almost certainly include closer cooperation with neighboring Romania, of which Moldova was a part until it was forcibly annexed by the Soviets during World War II. Closer cooperation with Romania would benefit Moldova's chemical industry, since on its own it has poor prospects for modernization and expansion.

Emerging business opportunities

Despite the tough times ahead for the republics' chemical industries, Western chemical firms will find an increasingly diverse and attractive array of business opportunities during the 1990s. These opportunities include not only the trade and joint-venture activities already being conducted, but also new possibilities—such as mergers with and acquisitions of former Soviet chemical facilities, fully owned Western subsidiaries, and practically the full range of business transactions known in the West.

New horizons also will open up as Western exporters and importers gain direct access to the output of individual facilities, rather than the past practice of working with centralized foreign trade organizations. And individual republics are expected to alter their foreign investment laws in an effort to woo much-needed Western capital. In some instances, republics may find themselves in direct competition with other republics or with certain East European countries for Western investment. Such competition will improve opportunities for Western investors, by providing tax holidays and other favorable concessions. Opportunities in the former Soviet chemical industry in the 1990s will be different, however, in different sectors of the industry.

Although the former Soviet Union was a leading world producer of many basic inorganic chemicals, it was not one of the most modern producers. Thus, many of the existing facilities will not make attractive joint-venture or takeover targets since they embody older technologies. For example, most sulfuric acid plants are obsolete units supplied by Poland more than a decade ago, and chlor-alkali units mainly use old, mercury-cell technology. Some exceptions might include the Kalush "Khlorvinil" Enterprise in the Ukraine, a relatively modern chlor-alkali complex; the Volgograd caustic soda production association in Russia, for which the Japanese are supplying equipment for a caustic soda unit due on stream in 1992; and some newer soda ash and ammonia units at Achinsk, Berezniki, and Togliatti in Russia, Krasnoperekopsk in Ukraine, and Grodno in Belarus. The most attractive opportunities for bulk inorganic chemicals in coming years will be in Russia and Ukraine, given the sizable number of large-scale and somewhat modern producers located there.

The former Soviet Union was also the world's largest fertilizer producer and exporter, but its output consisted mainly of single-nutrient products like urea, ammonium nitrate, and superphosphates. Most of its fertilizer producers are not attractive joint-venture partners or takeover targets because they have old facilities and usually embody less desirable Soviet or East Euro-

Four republics accounted for more than 90% of Soviet chemical output in 1990

	Share of Soviet chemical output, %	Estimated value of chemical output ($ billions)	Share, %	Estimated per capita chemical output (in dollars)	Index (U.S.S.R. average = 100)	Market size (population in millions)	Share, %
Russia	64.7%	$55.0	64.7%	$373.0	127.3	148.5	51.2%
Ukraine	17.8	15.1	17.8	290.0	99.0	51.9	17.9
Belarus	5.8	5.0	5.9	490.0	167.2	10.3	3.6
Transcaucasus (Armenia, Azerbaijan, and Georgia)	3.6	3.1	3.6	197.0	67.2	16.0	5.5
Kazakhstan	3.1	2.6	3.1	157.0	53.6	16.8	5.8
Baltics (Estonia, Latvia, and Lithuania)	2.4	2.0	2.4	252.0	86.0	8.0	2.8
Central Asia (Kirghizia, Tajikistan, Turkmenistan, and Uzbekistan)	2.4	2.0	2.4	61.0	20.8	34.2	11.8
Moldova	0.2	0.2	0.2	39.0	13.3	4.4	1.5
TOTAL U.S.S.R.	100.0%	$85.0	100.0%	$293.0	100.0	290.0	100.0%

pean technology. Notable exceptions include Togliatti in Russia, one of the world's largest nitrogen fertilizer complexes, with some newer units completed in the late 1970s and 1980s using Western technology; Gorlovka in the Ukraine; Bereznikі in Russia; and Kemerovo in Russia, where the Italian engineering firm Tecnimont supplied 500,000 metric-ton-per-year urea units during the 1980s; and Dorogobuzh, Novgorod, and Rossosh in Russia, where the Japanese supplied large nitrogen-phosphorus-potassium units during the 1980s.

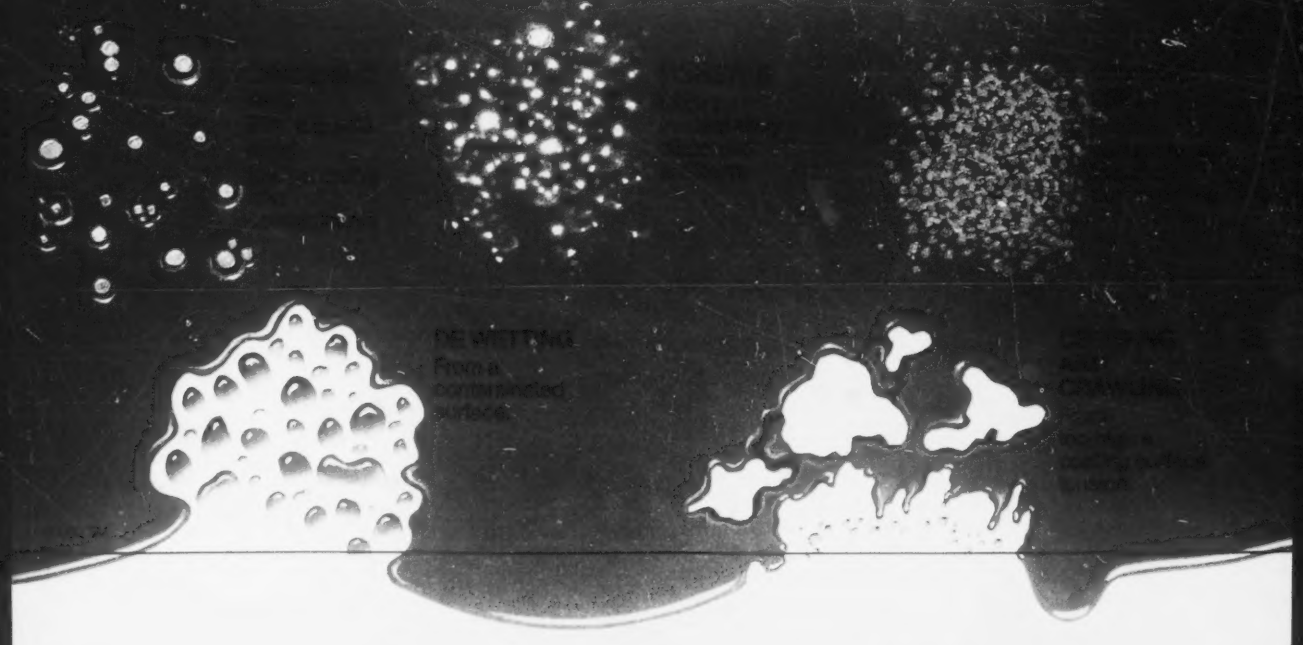
The former Soviet republics will be a good market for Western producers of plant pesticides in coming years. A recent joint venture involving such chemicals between the British firm ICI and farms in Ukraine illustrates the possibility for mutual benefit even in the present chaotic economic situation. The venture, basically a barter arrangement, provides for Ukrainian sales of agricultural products in order to purchase agrochemicals and other products from ICI. These chemicals, in turn, likely will help raise Ukrainian agricultural yields. Indeed, Ukraine, with its large agricultural base, would seem a natural candidate for both direct sales of plant pesticides as well as joint ventures in this area.

The plastics sector, which has already been slated for considerable investment in coming years, holds vast opportunities for Western business. Current plastics consumption, just a fraction of Western levels, will rise rapidly as economic restructuring leads to greater use of plastics in applications such as packaging, construction materials, machinery and vehicle manufacture, and consumer goods. Even current plans for adding more than 1 million metric tons to plastics capacity in the former Soviet republics during the 1990s will be insufficient to keep up with soaring demand. Thus, attractive export opportunities can be expected for Western and some Eastern European producers in the short term. This is particularly true for more processed forms of plastics and for more sophisticated products like engineering plastics.

In the longer term, even greater opportunities exist for Western firms to assist in building new plastics capacity or to acquire existing plastics producers. There are a number of good potential takeover targets in plastics, especially since this was a priority sector for investment in recent years. Republics that show the most promise in this sphere are Russia, Ukraine, Kazakhstan, and Azerbaijan.

Chemical fibers are not a promising sector for Western investment. Demand for chemical fibers is expected to remain weak for much of the 1990s, as the textile sector is hit hard by economic restructuring. Domestic producers of chemical fibers are not very modern or sophisticated: The percentage of three relatively progressive fibers—polyester, acrylic, and polypropylene—in total chemical fibers output in 1990 was a very low 32%. Thus, there are relatively few attractive takeover targets or joint-venture partners. Notable exceptions include the new Blagoveshchensk complex in Russia, which will start up polyester fiber production in 1992. This plant is being built by a Japanese firm and will

Problems.



use a Du Pont process. Other attractive projects are the large Mogilev polyester fiber complex in Belarus, which has been expanded in recent years, and the Novopolotsk complex in Belarus, where new acrylic fiber capacity was added in the late 1970s by Western firms. The most attractive republic for chemical fibers is Belarus, which produces an impressive amount of synthetic fibers, especially polyester and acrylics.

The paint and dye sector is also a good one to stay away from, thanks to the extremely old age and backward state of existing facilities throughout the former U.S.S.R. Almost no new paint or dye capacity was built during the 1980s, and a disturbingly large part of existing capacity dates from before the 1960s. Beginning in the mid-1990s, however, good sales opportunities likely will develop for Western suppliers of these products. This is particularly true for paints, since by that time a more competitive environment will necessitate better quality paint for use on manufactured goods. Domestic paint output will hardly be able to meet this new demand since much existing capacity will likely be shut down.

Beginning in the late 1990s, Western firms may find it attractive to build new paint and dye plants in the republics to feed the growing demand for high-quality output. But the high degree of sophistication of paint manufacture in the West and the transportability of these small-batch products may lead Western paint and dye makers to continue exporting output produced in the West.

Pharmaceuticals will be revolutionalized in the former Soviet Union in coming years by rapid expansion in Western investment, particularly in over-the-counter products. The shortage of medicines is so acute that even precious hard currency and oil have been used in recent years to import pharmaceuticals. Thus, Western drug manufacturers likely will find excellent sales opportunities for products ranging from simple over-the-counter drugs to more sophisticated medications for cancer and heart and other chronic diseases. Western firms also have the opportunity to replace East European suppliers of pharmaceuticals to the republics, since the East Europeans' previous advantage of selling their medicines for rubles rather than dollars on the domestic Soviet market was eliminated in early 1991.

Western firms are also likely to set up production facilities in some republics in coming years as demand increases. Some acquisition of existing producers might take place, but most Western firms will prefer to set up their own pharmaceutical production and distribution centers. Perhaps no other sector of chemicals will offer such vast opportunities to Western investors as pharmaceuticals in the coming years. Republics that offer the best opportunities in pharmaceuticals include Russia and Ukraine (because of their huge market size) and the Baltics and Belarus (because of their relatively high living standards).

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as much promise as pharmaceuticals. Here, too, there is a lot of unsatisfied demand for these consumer-oriented chemicals. These chemicals are still something of a luxury throughout the republics, however, and will remain so until the buying power of the average person rises to a decent level, something that will take well into the 1990s.

Thus, sales by Western producers will remain rather modest over the next few years and will be directed at the emerging upper class under the new market system. As in the case of pharmaceuticals, Russia, Ukraine, the Baltics, and Belarus will initially provide the best market for Western soaps, detergents, perfumes, and cosmetics. By the late 1990s, the economies of these and other republics probably will recover sufficiently to allow for much improved sales by Western producers, as well as some production of higher quality products within these republics.

Organic chemicals, which include a large number of bulk petrochemicals used to manufacture finished products, also offer a wide array of opportunities for Western companies. Russia and Kazakhstan, with their abundant oil and gas reserves, make natural candidates for large-scale petrochemical complexes. Western firms are expected to establish a number of joint ventures or wholly owned subsidiaries in these republics to produce various organic chemicals either for processing domestically or export. Because Eastern Europe is expected to de-emphasize its bulk organic chemical synthesis operations during the 1990s—now that it no longer receives Russian and Kazakh oil at below-market prices—Western firms may find these countries, as well as others further West, a potential market for bulk petrochemicals produced in Russia.

Demand for certain organic chemicals will be strong within Russia. Ethylene and propylene will be in demand to produce plastics, chemical fibers, and other products; and methanol may be in demand to help make methyl *tert*-butyl ether, used in the manufacture of unleaded gasoline. The market to other former Soviet republics during the 1990s will be much more limited because of their very large domestic production, but some spot sales may be possible.

Synthetic rubber demand will drop in coming years because of lower military expenditures. However, opportunities still exist in this sector. Demand for special-purpose rubbers will actually rise, since this type of synthetic rubber was underproduced in the former U.S.S.R., accounting for less than 20% of total rubber output. Demand for certain rubber products will increase as well. For example, more demand for cars and greater use of trucks to haul freight will increase demand for tires. Thus, Western tire firms, in particular, could find very lucrative opportunities for supplying the huge Russian, Ukrainian, and other markets.

Overall, the chemical industry of the former Soviet Union faces immense challenges during the 1990s as the economies of individual republics move to a market system. The magnitude and difficulty of these challenges are increased by the very poor state of this chemical industry at present. After more than 70 years of mismanagement under a faulty economic mechanism, one cannot help but wonder where the chemical industries of Russia, Ukraine, and other republics would be today had they been developing under a more rational economic system.

But present hard realities open up vast business opportunities for Western chemical firms. Western capital will be needed to rebuild and restructure the chemical industry of all the republics. Western suppliers of chemical products should see continued and expanding sales opportunities in the 1990s, especially for small-batch and specialty chemicals.

Although the Russians, Ukrainians, Kazakhs, and others lack hard currency to pay for new plants and chemical imports, innovative solutions exist. For instance, goods can be bartered, as Occidental Petroleum has done, exchanging its superphosphoric acid for Russian and Ukranian ammonia, urea, and potash. This particular agreement, signed in 1973 and intended to continue through 1997, foundered on the political and economic chaos of the region during the past year. However, it illustrates the potential value of barter arrangements in chemicals to both Western partners and former Soviet republics. A recent agreement to barter hundreds of millions of dollars worth of Polish pharmaceuticals and other consumer goods for Russian oil and natural gas offers another example of the possible future importance of barter to Russian chemical trade.

Another option for Western firms seeking to do business in the former Soviet republics is to accept a stake in the business by forming joint ventures. Though business conditions are extremely risky at present, this risk can be reduced by a series of measures, including minimal up-front investment and careful choice of location and sphere of activity. Moreover, the long-term growth potential for this huge market of nearly 300 million consumers is simply too great for many Western chemical makers to ignore. □

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